Needs for future experimental testing in Aeroacoustics

– DNW Symposium Future Needs - The next 20 years –

14 March 2018, DNW-LLF Marknesse

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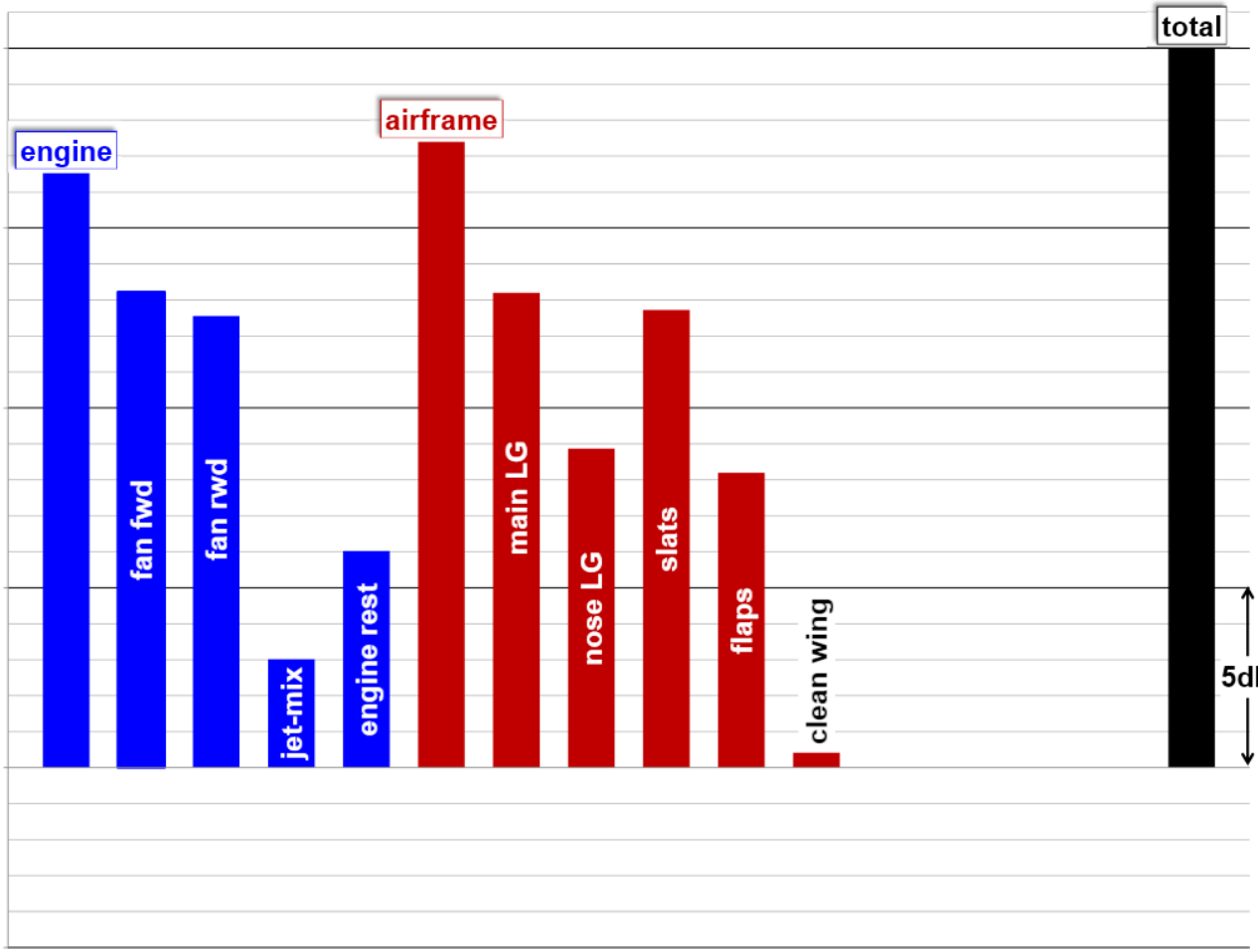
DLR

Outline

- **Future challenges in aircraft noise**
- **Needs for future aeroacoustic testing**
  - facility wise
  - process-wise: is it necessarily “experiment” vs. “numeric”?
- **Conclusions**

Noise sources – the classical view on modern tube&wing a/c configurations

Short to medium range aircraft, BPR 10-12, approach



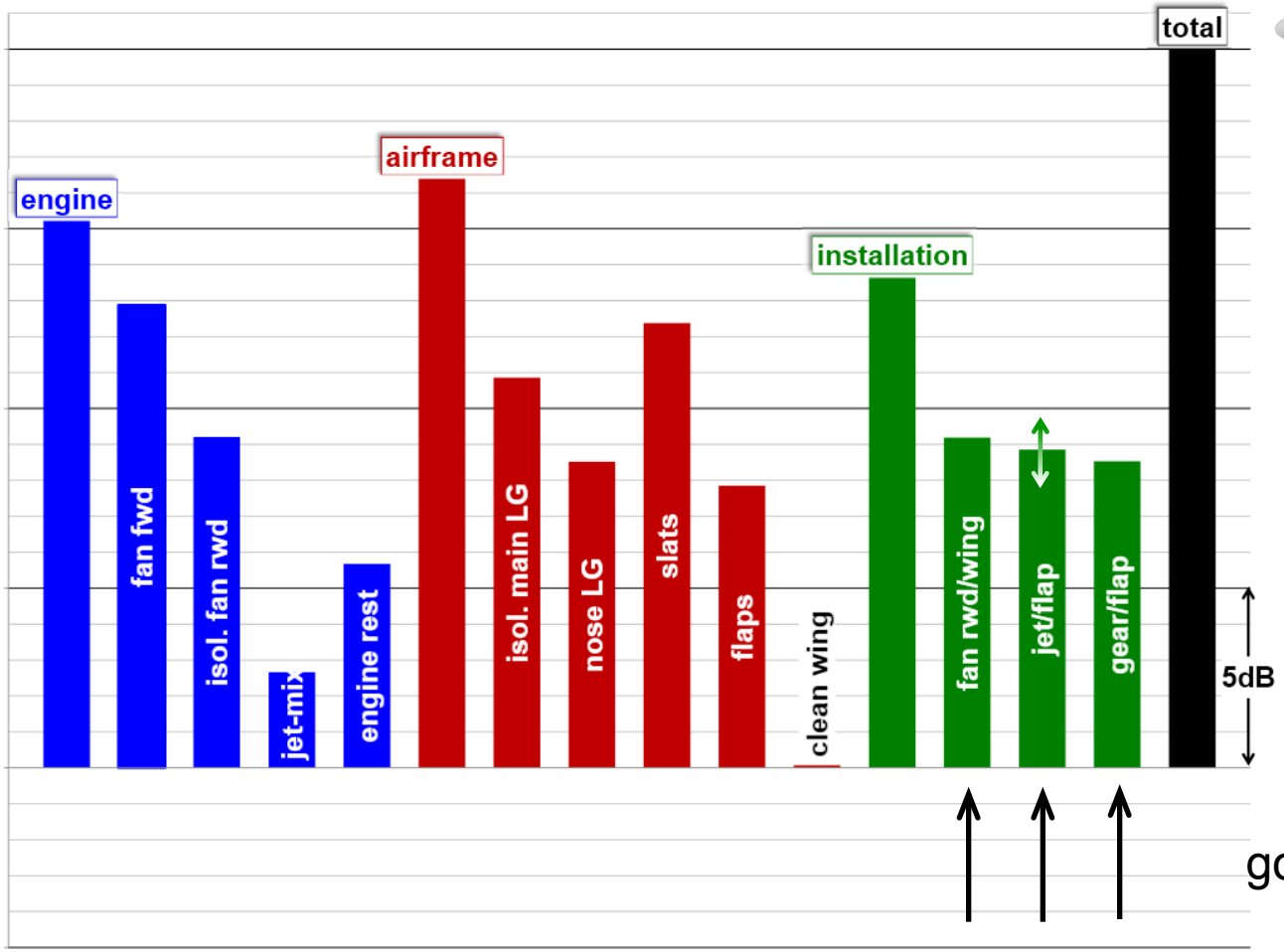
„classical“
source breakdown

Delfs 2016

engine/airframe source breakdown: Airbus 2015

Installation sources – a view on modern tube&wing a/c configurations

Short to medium range aircraft, BPR 10-12, approach



„complete“
source breakdown

good estimate?

Classical component noise research – sufficient?

? How does the generation sound at components change when operated under actual a/c installation conditions?

? What is single component noise reduction technology worth if installation is ignored?

? How does the presence of an actual a/c change the radiation of the component sources?

! Component source testing important but insufficient.

! Installation effects (source wise + radiation wise) need to be considered too.

⇒ (**best**) use very large acoustic facilities to arrange for representative
* aerodynamic interactions of components (moderate requirement on wt size)
* acoustic radiation effects (severe requirement on wt size)

⇒ (**alternative**) think of new ways of using mid size facilities

How about true a/c noise reduction / FP2050 goals?

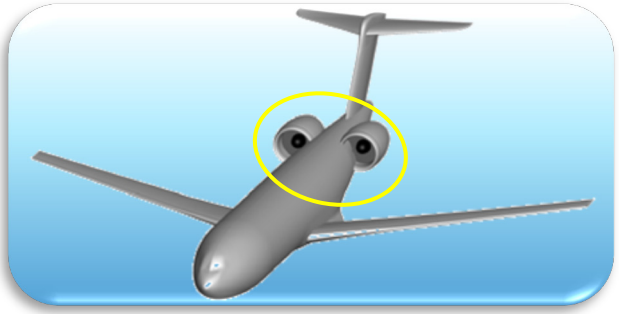
! a/c noise reduction limited when restricting to low noise component technology at conventional aircraft

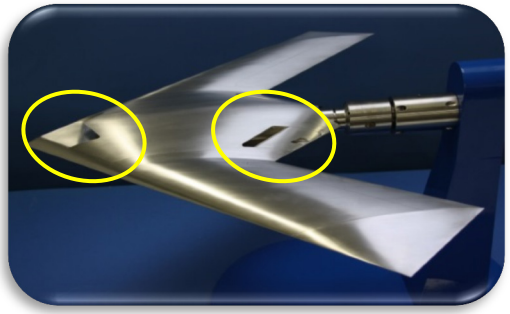
! Drastic a/c noise reduction realistic only if aircraft configuration is taken into account : a/c configuration ↔ noise reduction technology

? How do we know whether our guesses (based on preliminary design empirical models) are correct for „cool“ low noise a/c?

⇒ High fidelity simulation of complete a/c (!extreme challenge to HPC!)

⇒ Experimental simulation of complete a/c (!extreme challenge for model technology!)



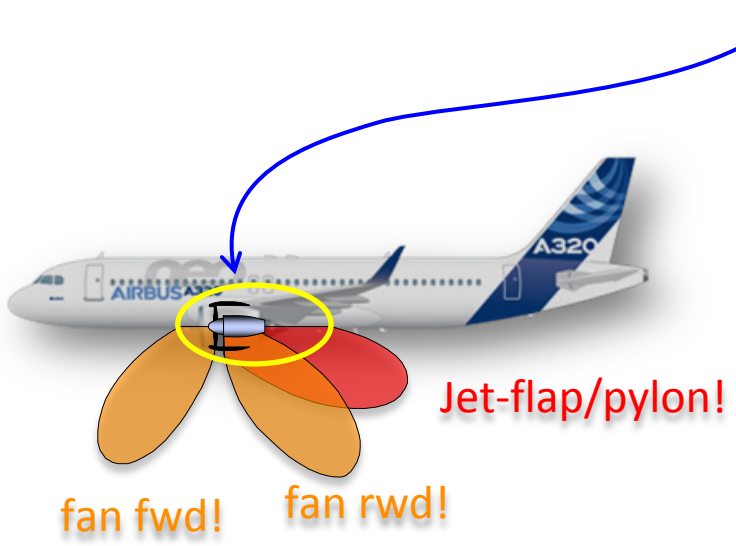


Testing complete aircraft noise in wt

! Test environment for the investigation of Noise and Performance of complete aircraft including new aircraft configurations

! Key technologies:

- Acoustic windtunnel of excellent quality and sufficient size (≥3m)
- aeroacoustically similar turbofan simulators (ATS)
- pressurized air for the operation of ATS

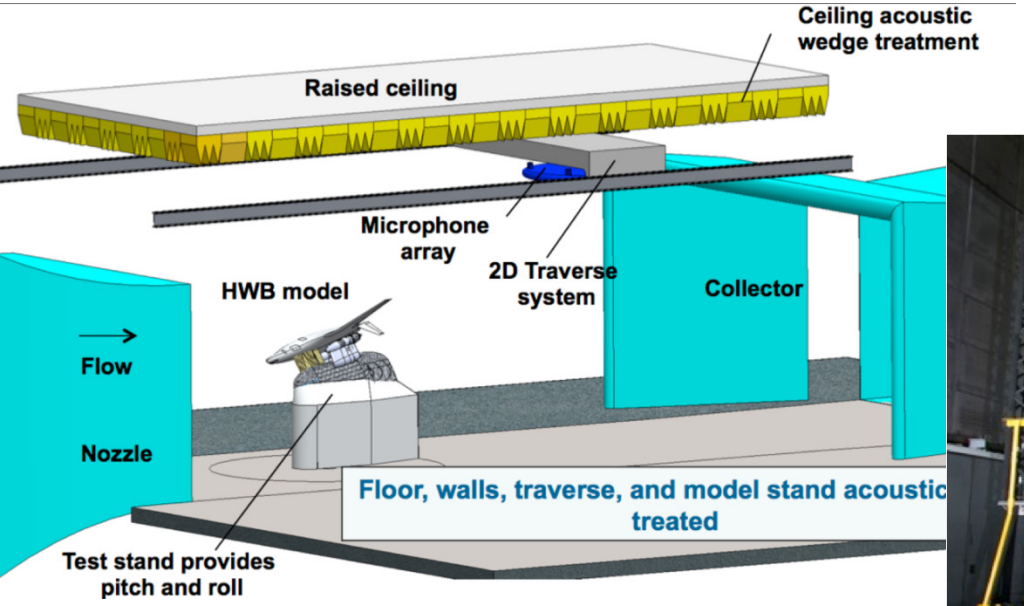


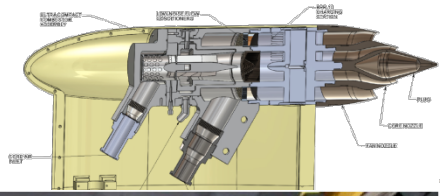
Example: Installed CROR in DNW-LLF
(aeroacoustically similar CROR!)

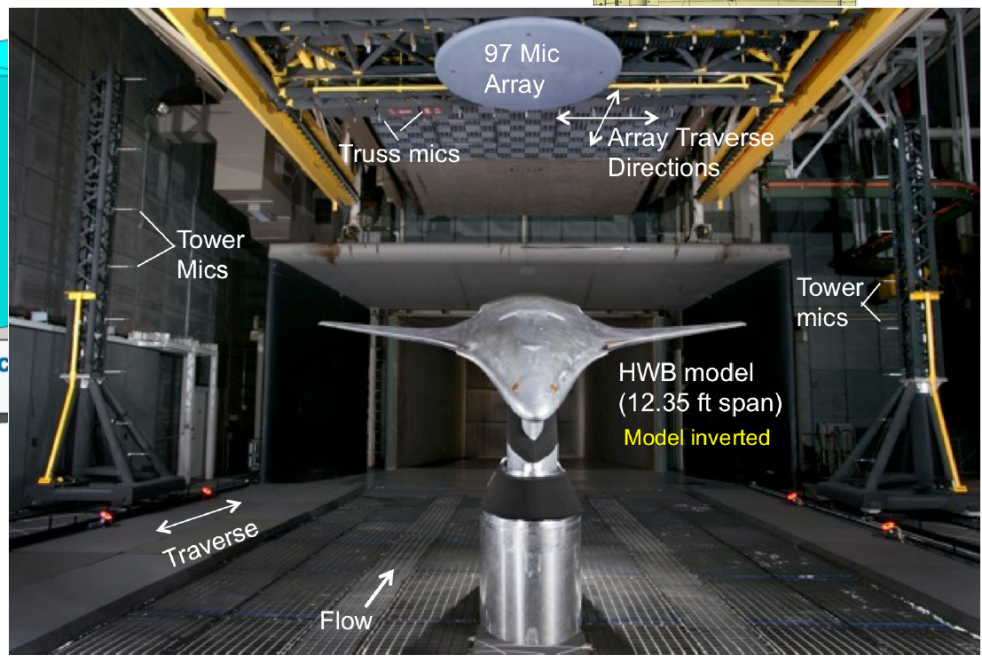
Testing on complete aircraft for selected sources in wt

NASA ERA program: low noise N2A HWB aircraft validation test

- NASA LaRC 14x22 tunnel equipped with treatment
- aeroacoustically similar jet noise simulators (hot dual stream), „CJES“
- displacement body instead of nacelle: no fan source







M. Doty, Th. Brooks, C. Burley, Ch. Bahr, D. Pope. AIAA 2014-2625

Testing complete aircraft noise on half model in wt

! Test environment for the investigation of Noise and Performance of complete aircraft including new aircraft configurations

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- Acoustic windtunnel of excellent quality and sufficient size (≥3m)
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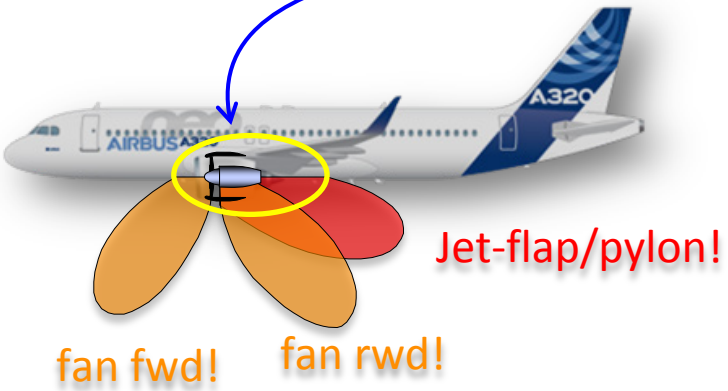
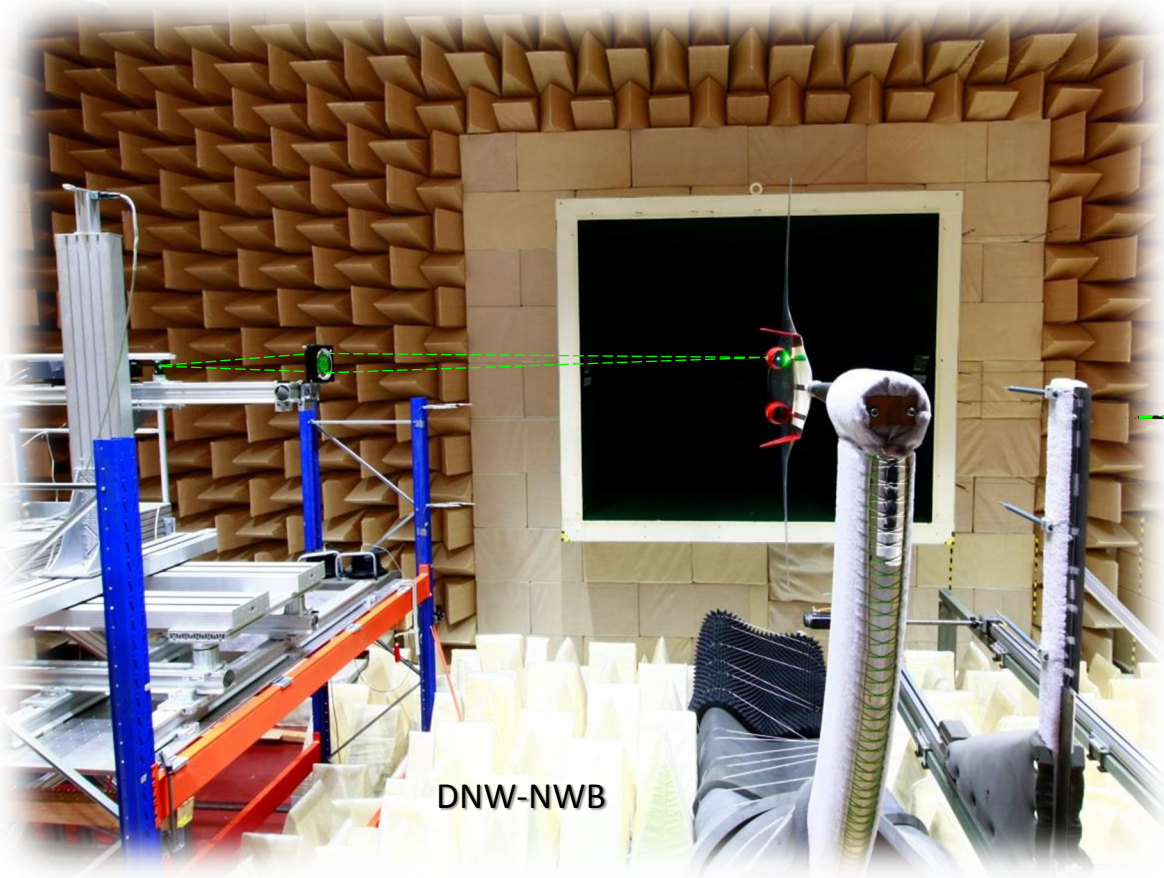
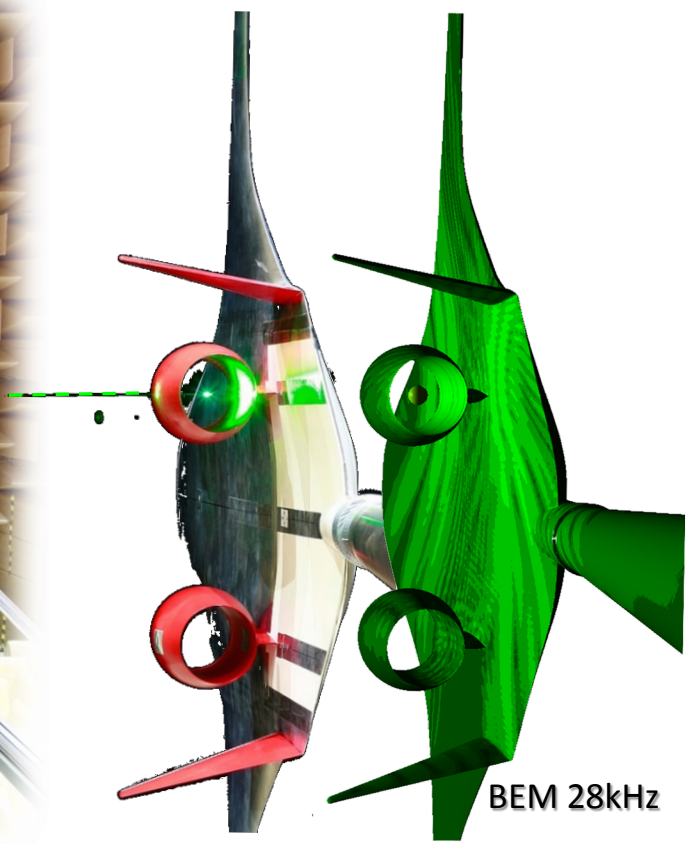


Example: aircraft in DNW-NWB

Testing on complete aircraft for generic sources in wt

Acoustic Shielding NATO AVT 233



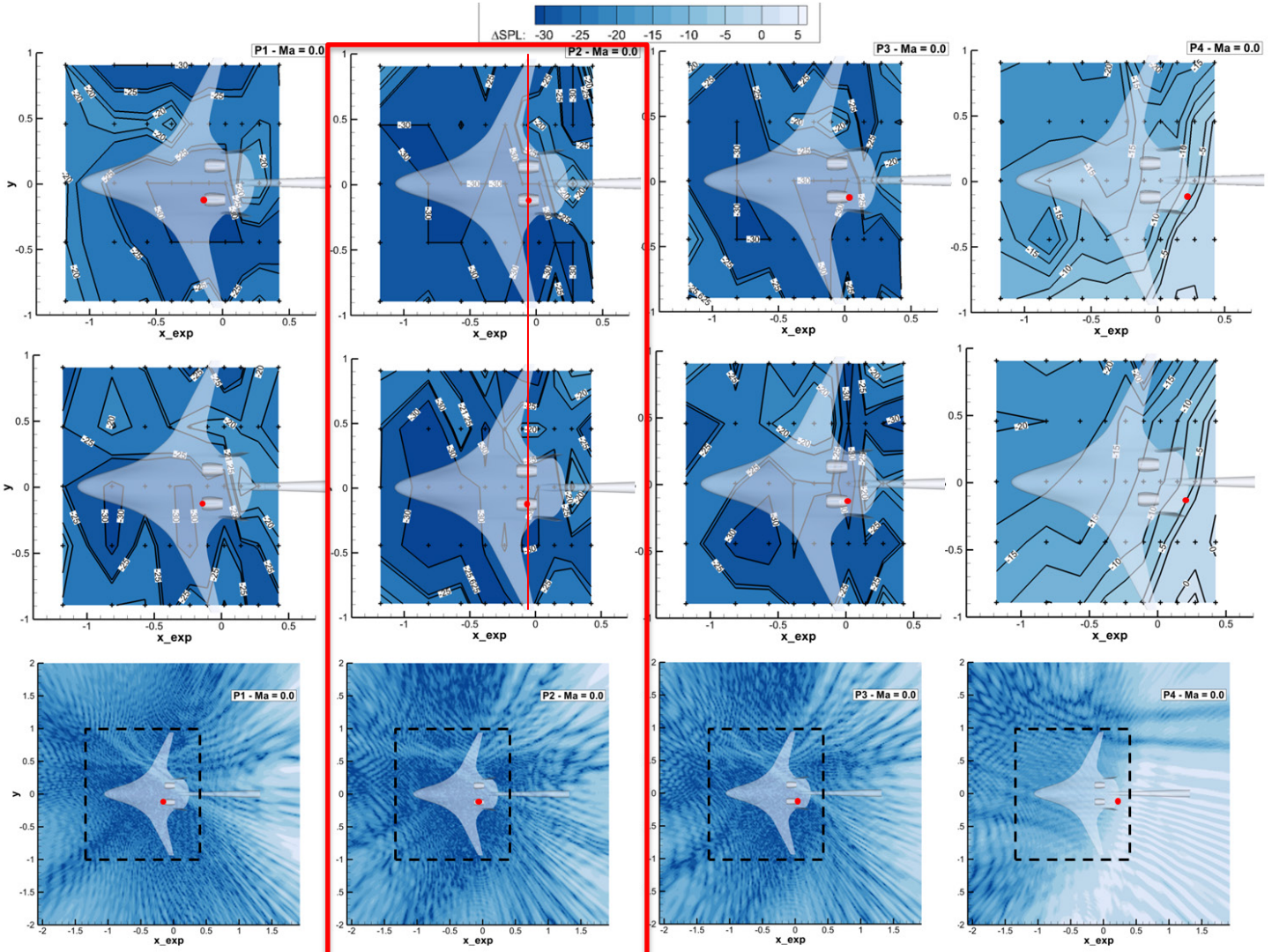


Testing on complete aircraft for generic sources in wt

Exp.

Comp.

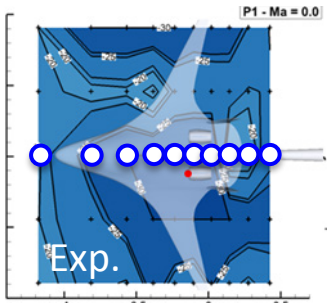
Comp.

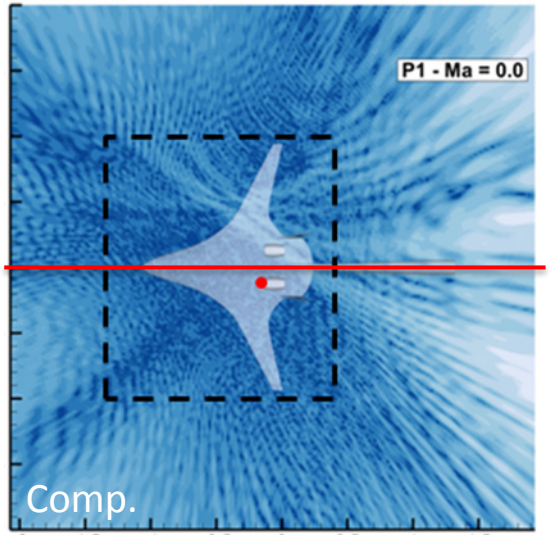


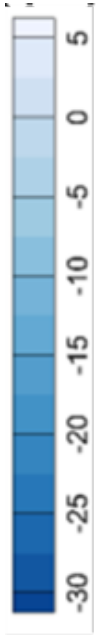
K.-St. Rossignol, M. Lummer 2017

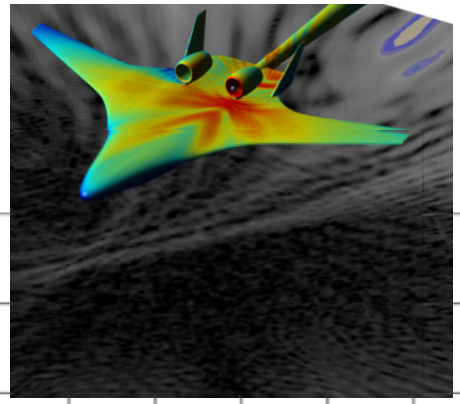
Testing on complete aircraft for generic sources in wt

Acoustic Shielding NATO AVT 233





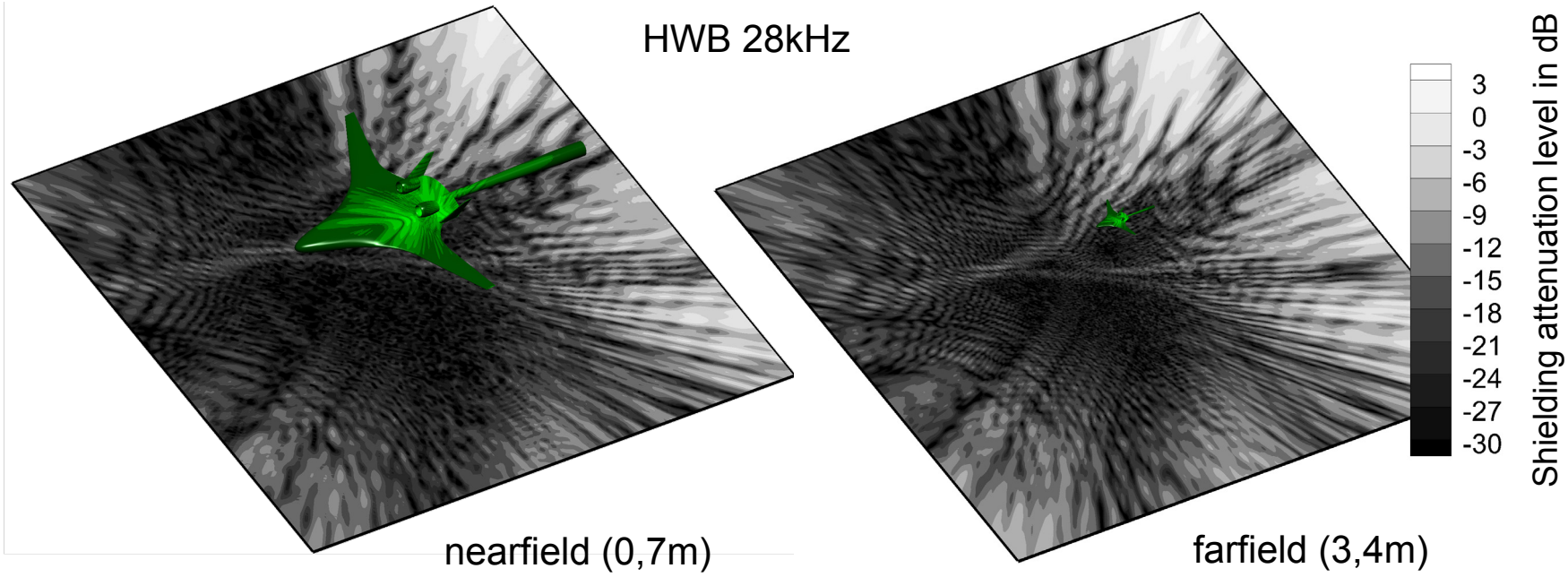




K.-St. Rossignol, M. Lummer, J. Delfs 2017

Near field measurement?

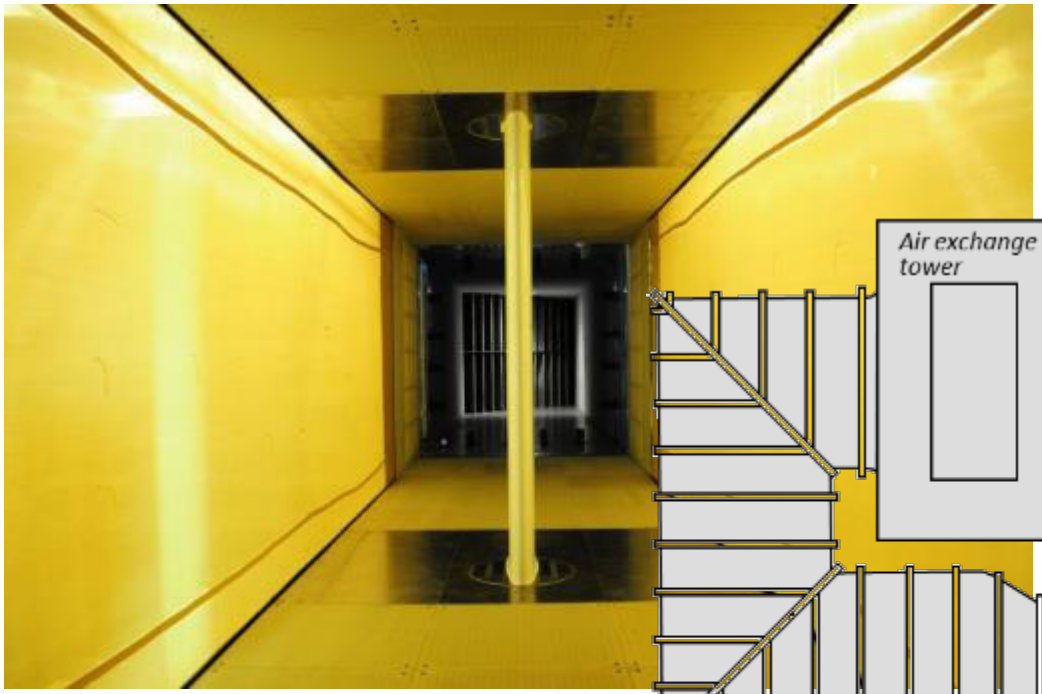
- complete a/c models (incl. model turbofans) in acoustic wt / closed section wt:
  ⇒ small scales ⇒ very high frequencies ⇒ inflow mics ⇒ geom. Nearfield
- requires inflow mics with omnidirectional characteristics!



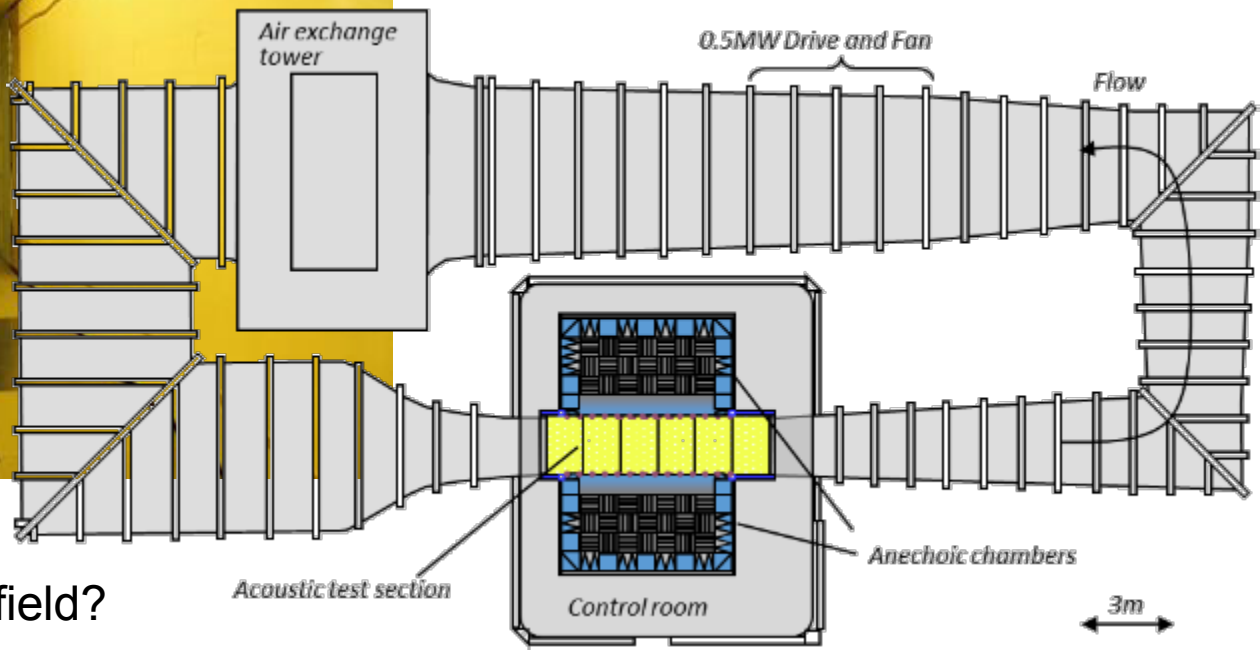
⇒ measure + validate in nearfield, simulate farfield

Future Aeroacoustic Test facility = Kevlar walled tunnels?

! Hybrid wind tunnel concepts: acoustically transparent walls.



Virginia Tech Stability WT



⇒ potential to measure in farfield?

⇒ complete Kevlar cage test section?

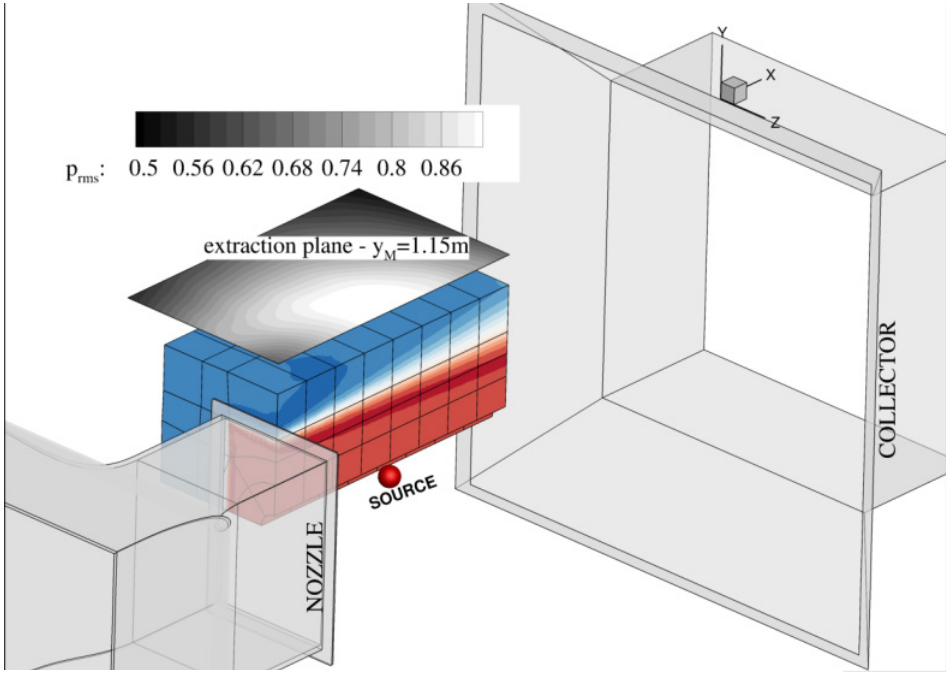
⇒ why does this exist in US and Asia only?

W. Devenport, R. Burdisso, A. Borgoltz, P. Ravetta, M. Barone, K..Brown, M. Morton, JSV 322 (2013) 3971-3991

CAA based acoustic open wt corrections (AWB)

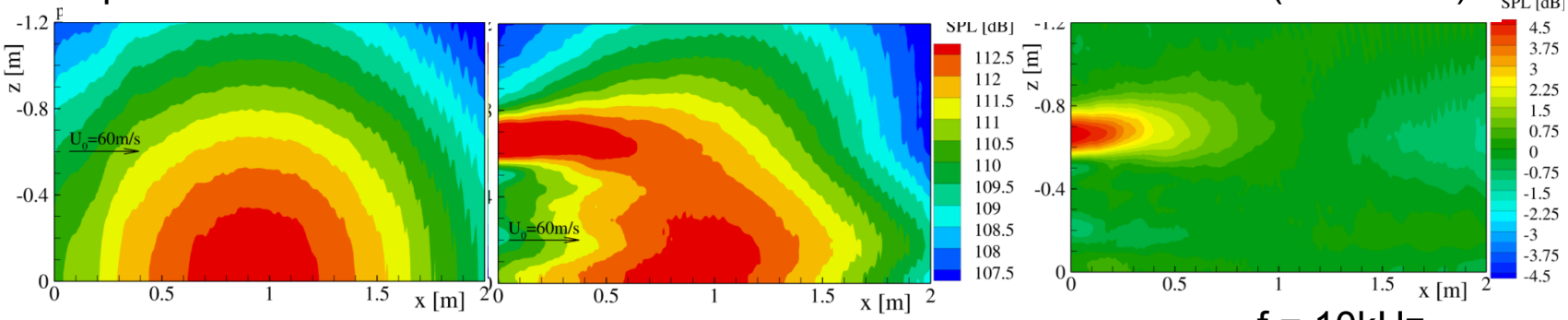
use numerical simulation + HPC to correct for (un)steady WT shear layer effects

Extend range of receiver positions by exploitation of numerical simulation



planar shear flow | AWB shear flow | difference (correction)

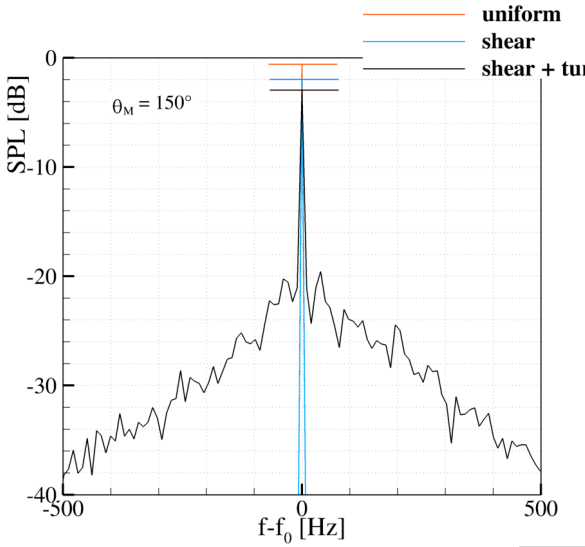
60m/s

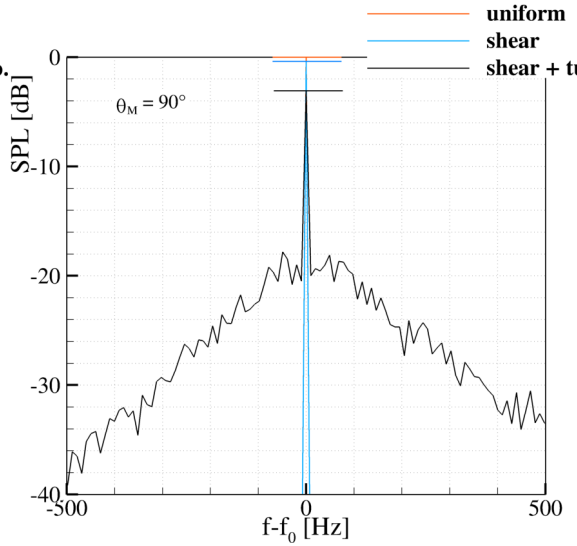


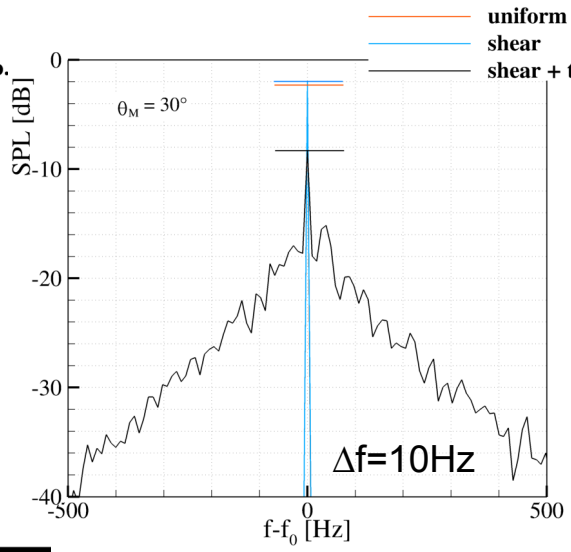
f = 10kHz

Diss. J. Jiao, 2017

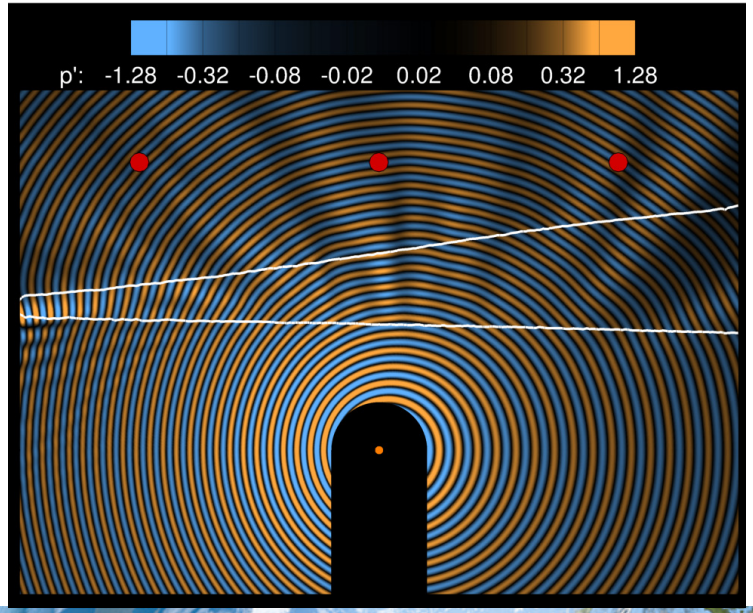
Acoustic open wt corrections (AWB) using CAA







use numerical simulation+HPC to correct for (un)steady WT shear layer effects

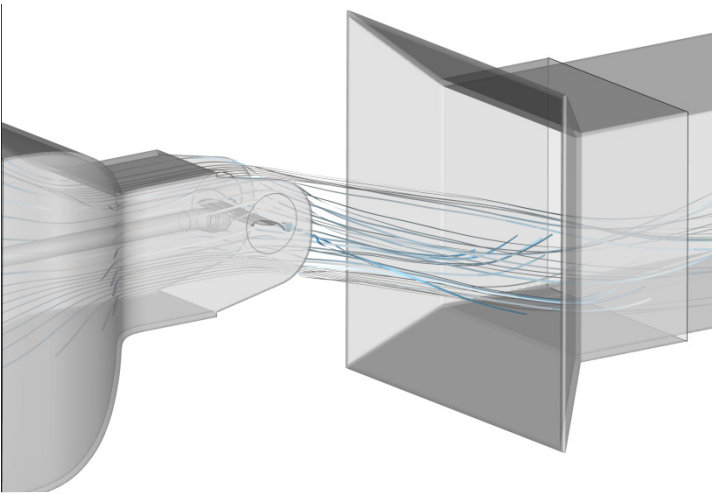


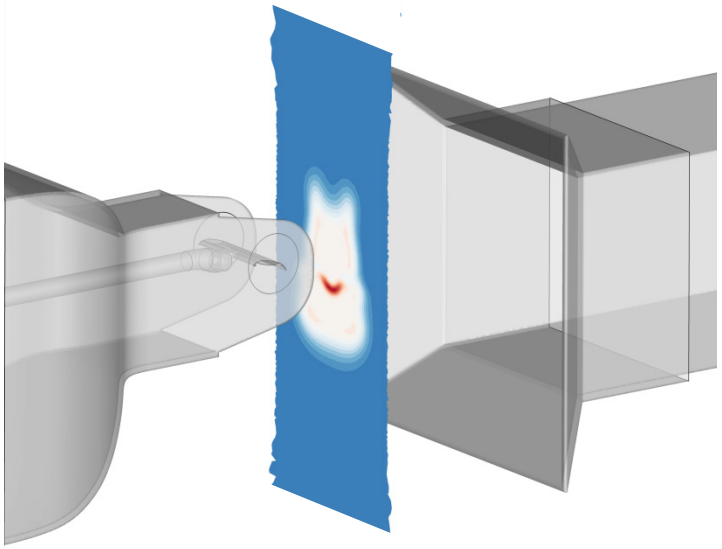
Include tone **corrections** from scattering **based on numerical simulation**

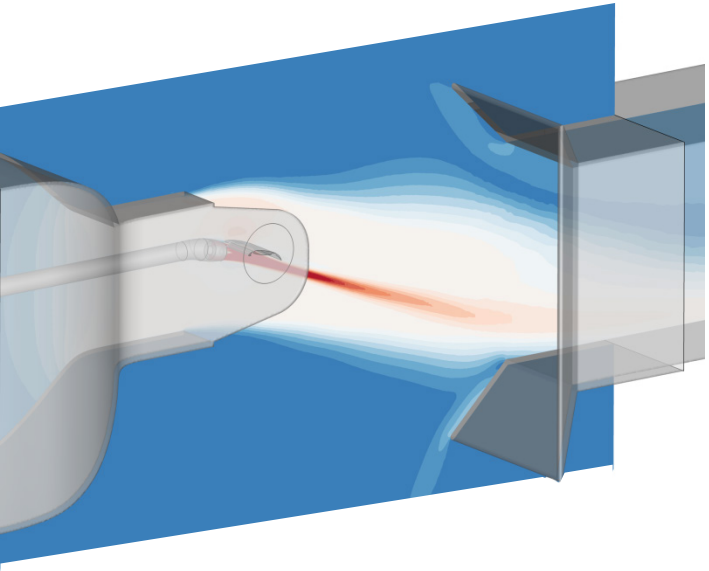
TAU + FRPM+PIANO

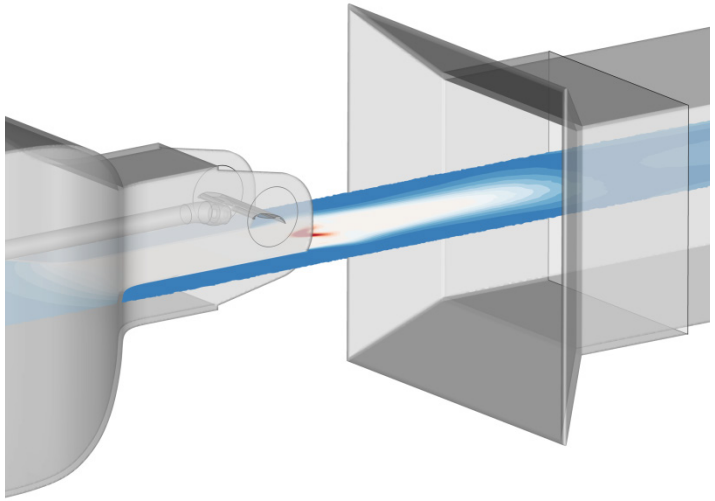
Diss. J. Jiao, 2017

Large component acoustic testing in open wt





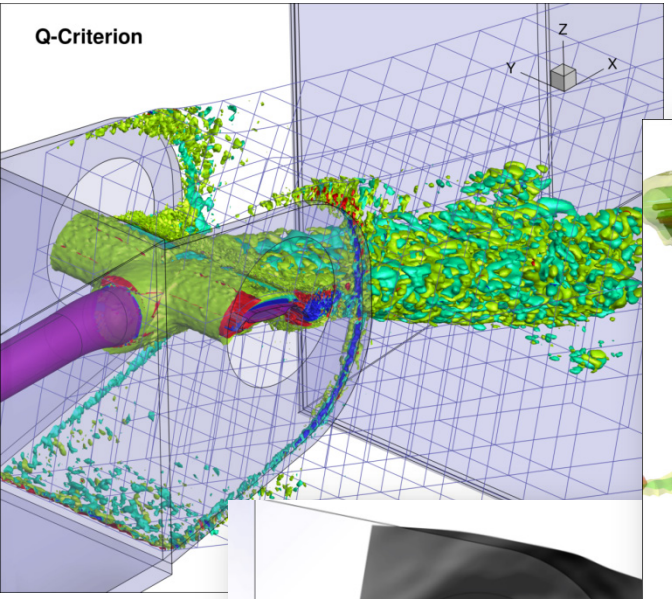


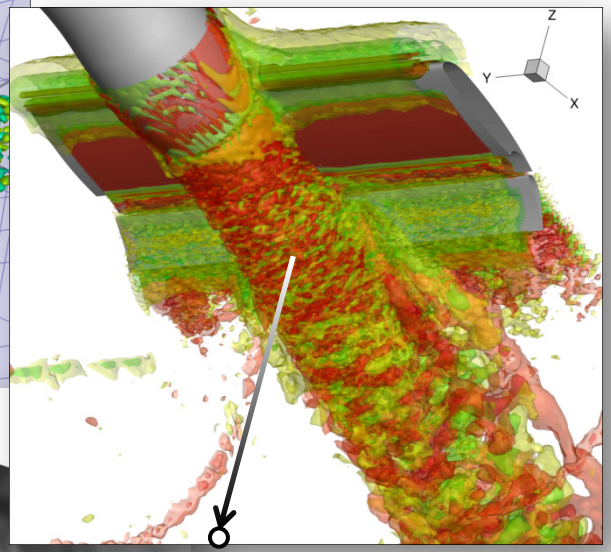


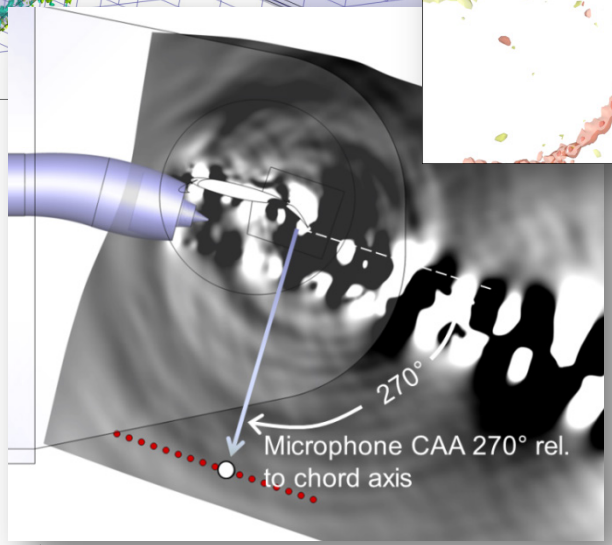
D. Boenke, J. Delfs, Lufo Power25 2017

Large component acoustic testing in open wt – validation

CAA of UHBR dual stream jet combined with 2D high-lift wing incl. AWB

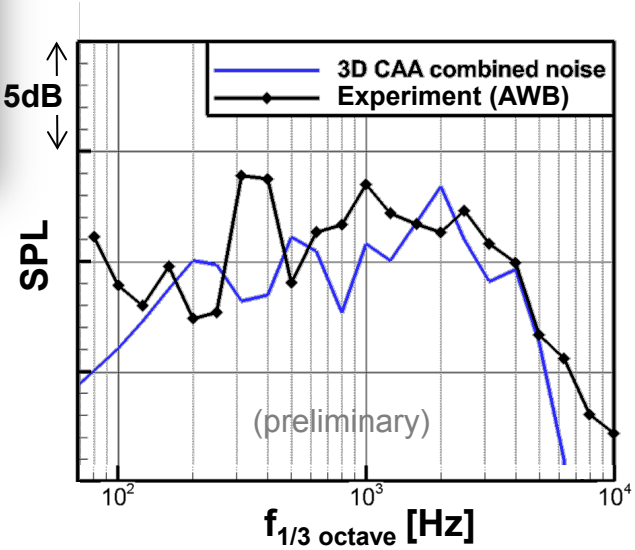






PIANO: FES=„Forced Eddy Simulation“

simulate model + test environment
validation on raw data
„do the whole thing“

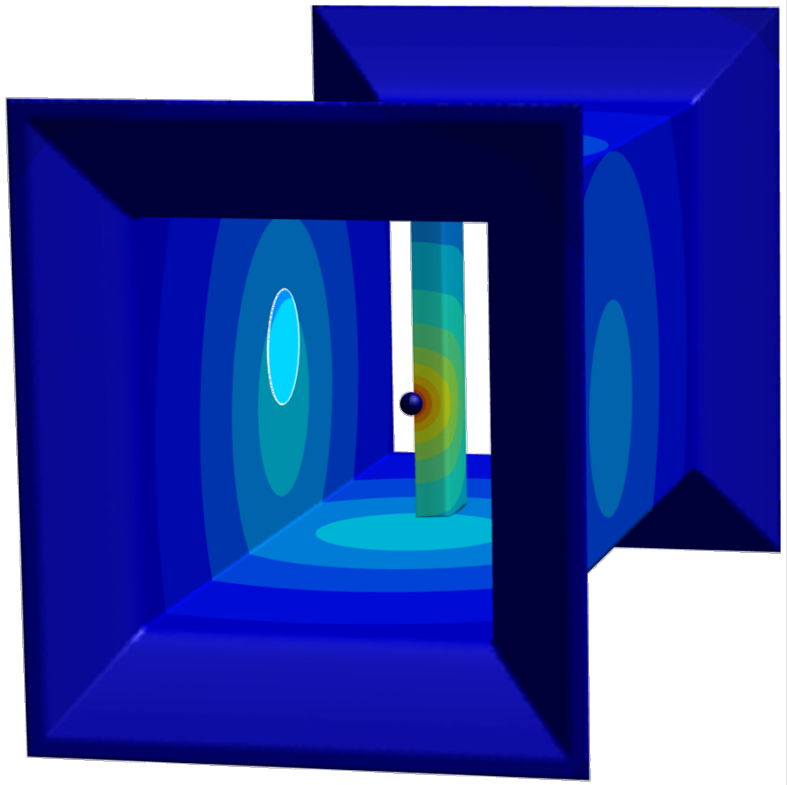


A. Neifeld, R. Ewert, EU-JERONIMO 2017
*) R. Ewert, AIAA2014-3053

Large component acoustic testing in closed wt

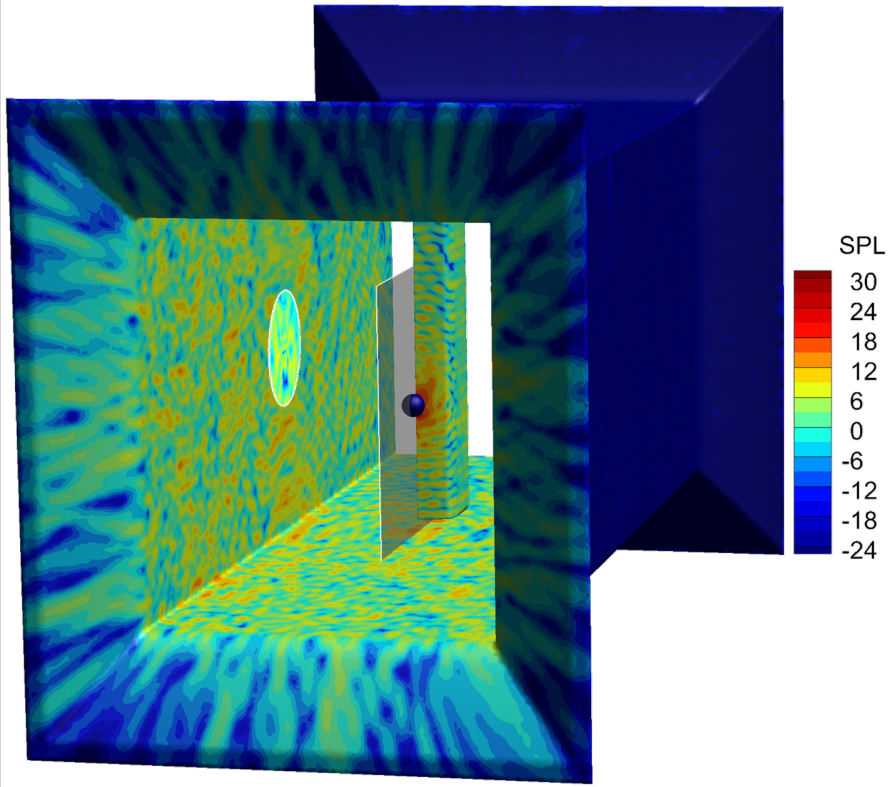
wall array measurements

incident surface pressure



Monopole - 1000 Hz

actual surface pressure



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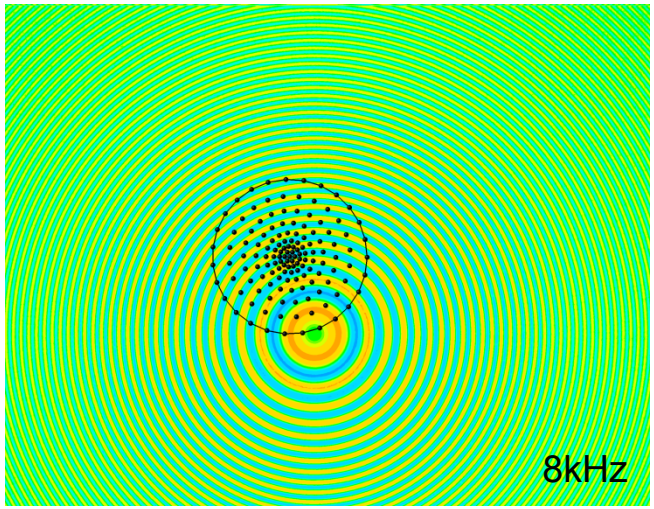
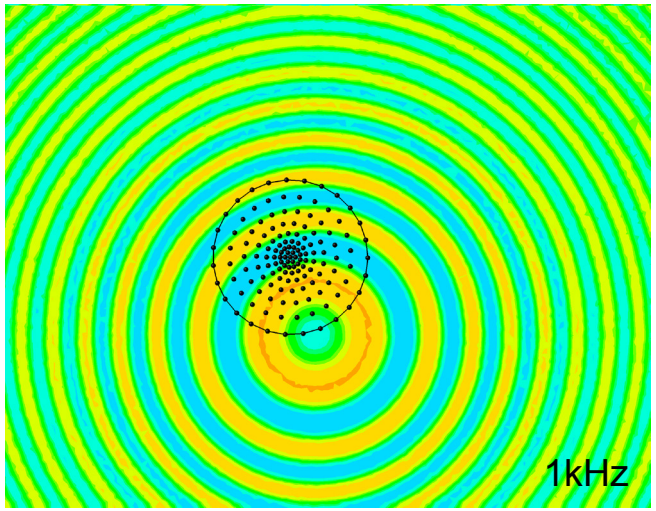
Large component acoustic testing in closed wt

incident surface pressure

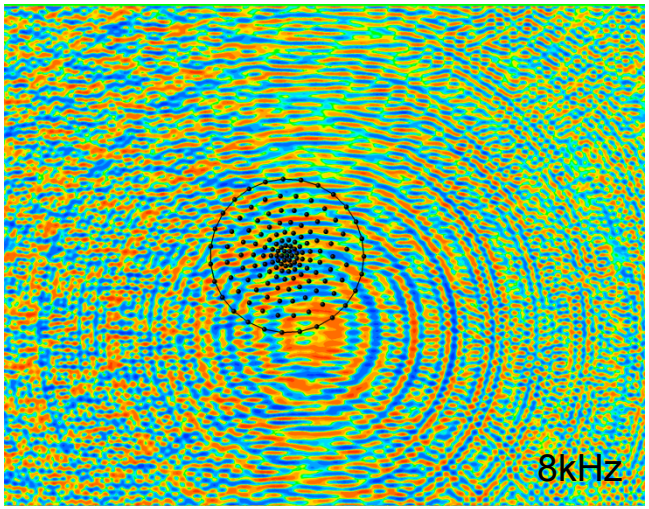


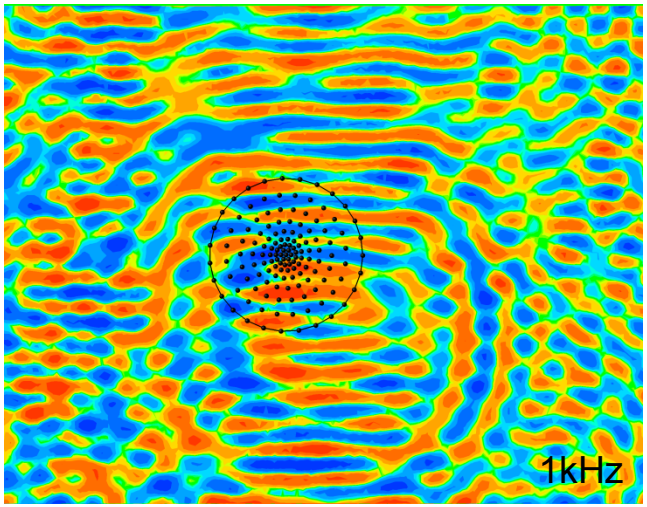


Fast Multipole BEM (FMCAS)

use numerical simulation+HPC to **clean up WT effects**

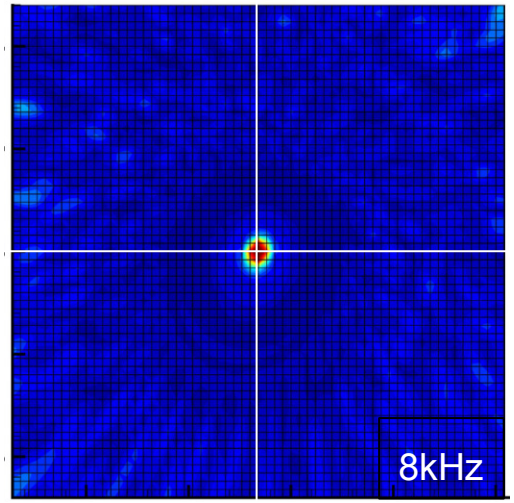
actual surface pressure

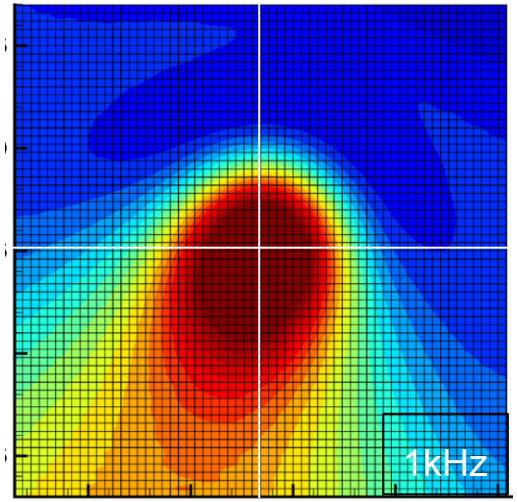




Large component acoustic testing in closed wt

incident pressure input

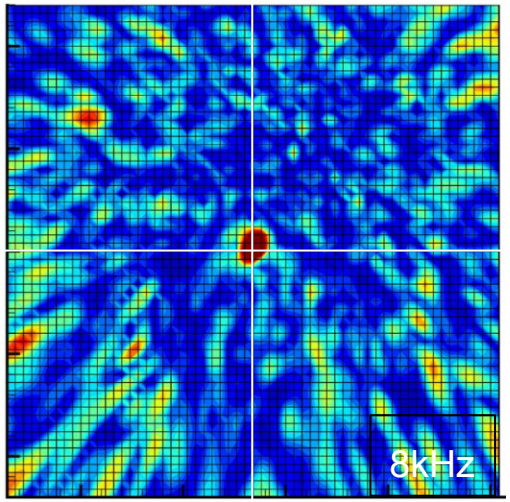


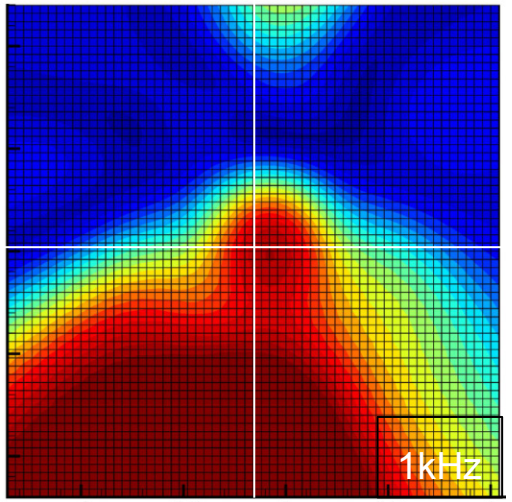


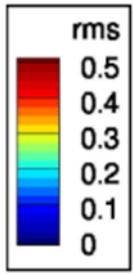
Fast Multipole BEM (FMCAS)

use numerical simulation+HPC to **clean up WT effects**

actual wall array pressure input

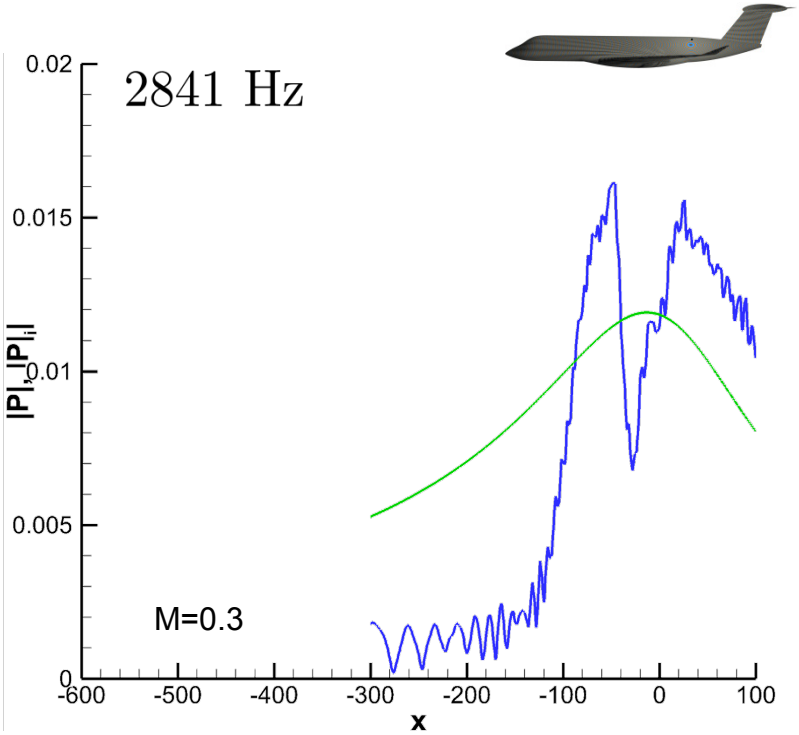






Outlook/ more open questions

Is noise reduction by shielding always „good“?



? is rapid (temporal) change of signal amplitude more relevant for perception than a reduction in SPL?

? For tone components installation creates strong amplitude fluctuations: problem?

! Realistic acoustic installation of tone sources important to assess noise impact

• Tone testing in acoustic wind tunnels extremely high challenge

Summary

- low noise a/c component technology remains important, but insufficient
- Installation effects influence overall aircraft noise significantly - source wise and radiation wise
- exp. validation of low noise impact a/c requires realistic engine (tone) sources
- validation of low noise a/c design: new challenges on exp. and num. side
  - more than one component needs to be considered (large domains)
  - small scale aeroacoustically similar turbofan simulators needed
- relevant farfield only by computation (wt tests to validate codes in nearfield)
- numerical Simulation / HPC may be used to „map test conditions to reality“

Conclusions

- Future progress for low noise a/c only when considering complete a/c

- Need possibility to experimentally simulate complete a/c noise in wt!
  - for realistic installation sources and radiation
  - for validation of new a/c concepts w.r.t noise and performance
  - key elements: Acoustic WT, Acoustic Turbofan Simulator, HPC

- Why don‘t we blend more experimental and numerical techniques?
  - simulate actual measurement situation (aero + acoustics)
  - improve wind tunnel correction with numerics and HPC
  - reduce ad-hoc assumptions in beamforming, by enriching with num. sim.
  - use PIV/STB to determine surface pressures from NS equations;
    use numerical simulation to determine sound field

DLR